THE CHEMISTRY OF VICINAL TRICARBONYL COMPOUNDS: ACTION OF GRIGNARD REAGENTS

by

EDSEL LEO MILLER

B. S., Kansas State College of Agriculture and Applied Science, 1948

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Chemistry

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1949

KANSAS STATE COLLEGE LIBRARIES

Document
LD
2668
T4
1949
M61
C.2

TABLE OF CONTENTS

INTRODUCTION..... 1

EXPERIMENTAL..... 11

Preparation of Vicinal Tricarbonyl Compounds..... 11

Reactions of Organometallic Reagents with Vicinal Tricarbonyl Compounds..... 14

DISCUSSION AND CONCLUSION..... 22

SUMMARY..... 25

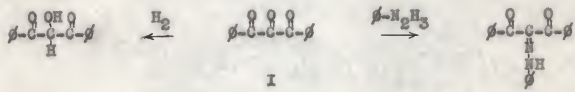
ACKNOWLEDGMENTS..... 26

LITERATURE CITED..... 27

INTRODUCTION

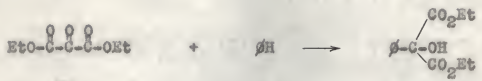
Reactions and the course of reactions of mono-functional compounds have been relatively well established, but the chemistry of poly-functional compounds has received much less attention until recent years, particularly in regard to the participation of neighboring groups during reactions. For this reason, it was chosen to observe the reactivity of a limited number of vicinal tricarbonyl compounds, that is, those containing three consecutive carbonyl groups.

The highly active nature of the middle carbonyl group of diphenyl triketone (I) has been shown by catalytic reduction with molecular hydrogen (2) to give dibenzoyl carbinol, and a reaction with phenylhydrazine (3) to give a phenylhydrazone attached at the center carbon.



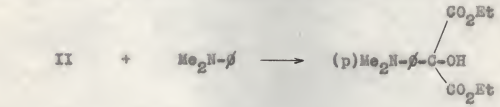
I

Additional evidence pointing to the highly active nature of the middle carbonyl group of a tricarbonyl compound is offered by several condensation reactions involving ethyl mesoxalate (II). Guyot and Esteva (6) showed that diethyl mesoxalate condensed with an aromatic hydracarbon in the presence of concentrated sulfuric acid to give a mono-aryl tartronate.

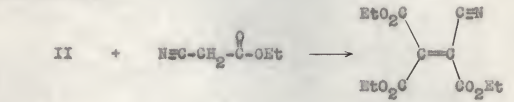


II

Guyot and Michel (7) obtained a similar reaction with dimethyl aniline and I in acetic anhydride or phosphorus oxychloride.



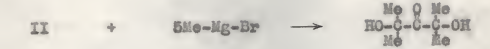
Schmitt (14) reports a condensation product from II and ethyl cyanoacetate.



Meyer (11) using II and phenylisoxazolone reported the product ethyl mesoxalate-bis-phenylisoxazolone.

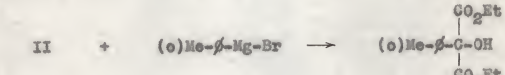
The only deviation from the theory that the middle carbonyl is the most reactive of the three was offered by Lemaire (10) in which he claims to have treated one equivalent of II with five equivalents of methyl magnesium iodide and isolated the compound

tetramethyldihydroxyacetone.



It should be noted, however, that Lemaire could not detect the presence of hydroxyl or carbonyl groups by the usual tests, and it seems probable that a compound other than the one reported was actually obtained.

Much more recent data concerning the reaction of a Grignard reagent with ethyl mesoxalate was published by Lapkin and Golovkova (9) in which they described the reaction of o-tolyl magnesium bromide with II to give diethyl o-tolyltartronate.

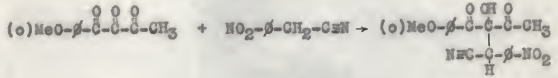


The reaction of ethyl benzoylglyoxylate (III) and hydroxylamine was observed by Wahl (17) to give the alphamonoxime.

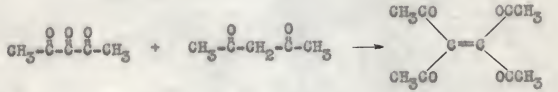
He reported that III reacted with phenylhydrazine to give an alpha-linked phenylhydrazone.

Additional reactions and products have also been observed with compounds of structure similar to diphenyl triketone (I), ethyl mesoxalate (II), and ethyl benzoylglyoxylate (III).

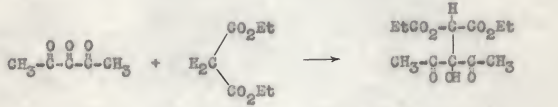
Sachs and Herold (12) reported that methyl o-anisyl triketone and p-nitro benzyl cyanide condensed in the presence of piperidine to give an addition compound linked at the central carbon atom.



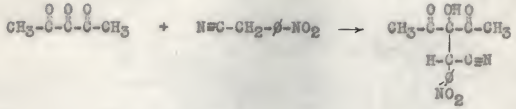
Sachs and Wolff (13) reported a series of reactions employing dimethyl triketone. This compound reacted with acetylacetone in pyridine to give the product shown.



A condensation between dimethyl triketone and ethyl malonate was also reported by them.

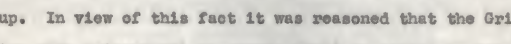


Para-nitro benzyl cyanide also gave a condensation product when it reacted with dimethyl triketone.



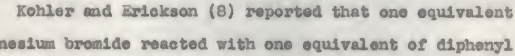
In all cases the middle carbonyl group took part in the reaction. It will be noted also that most of the reactants and conditions employed give support to the theory that an anionic (negative) particle is attacking the central (most active) carbonyl group. In view of this fact it was reasoned that the Grignard reaction with tricarbonyl compounds would be useful to examine, particularly since the R of R-Mg-X can act as an anionic particle.

Kohler and Erickson (8) reported that one equivalent of phenyl magnesium bromide reacted with one equivalent of diphenyl triketone (I) to give the benzoate of benzoin (IV).



IV

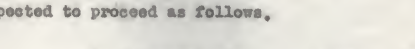
If however, an excess of phenyl magnesium bromide was used, the products obtained were triphenyl carbinol (V) and benzoin (VI).



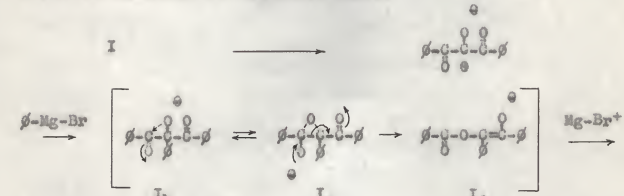
V VI

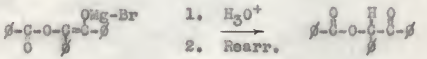
Manifestly, products V and VI are due to cleavage, and from the formation of V, it is evident that this cleavage occurs prior to

the final decomposition of the magnesium derivatives with acid. These products are unexpected since the normal course of reaction would be expected to proceed as follows.



In view of the findings of Kohler and Erickson (8) it was postulated that the benzoate of benzoin would be obtained from the reaction of one equivalent of phenyl magnesium bromide with one equivalent of diphenyl triketone if the reaction proceeded by the mechanism outlined and described below.

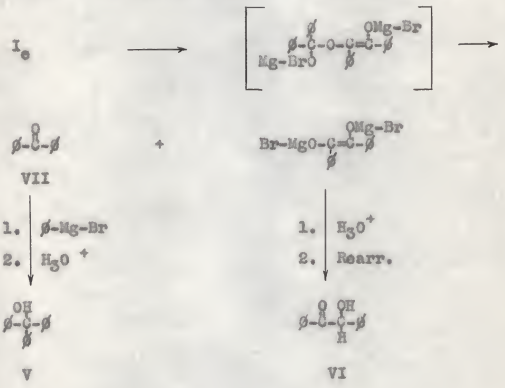




The resonating diphenyl triketone molecule would have a partial positive charge on the carbon of the center carbonyl group which would be attacked by the negative phenyl group from the phenyl magnesium bromide. The oxide type oxygen could attack an adjacent

carbonyl group and give rise to the formation of an ethylene oxide type ring. Those electron shifts within the anion are shown which could lead to the formation of the benzoate of benzoin (IV).

The reaction of an excess of phenyl magnesium bromide with one equivalent of diphenyl triketone might proceed in the same manner as the above reaction down to and including I_e.



The ester carbonyl group of I_e will react with an equivalent of phenyl magnesium bromide to give an addition compound which immediately decomposes to benzophenone and the di-salt of the ene-diol form of benzoin. The benzophenone could react with more phenyl magnesium bromide in the normal manner to give triphenyl carbinol (V). The di-salt of the ene-diol form of benzoin would rearrange when hydrolyzed to give benzoin (VI).

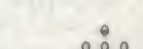
Note that this mechanism accounts for the fact that excess amounts of Grignard reagent with I failed to give anything but products V and VI.

From the report of Kohler and Erickson (8) it seemed reasonable that similar rearrangements might occur during the reaction of Grignard reagents with other vicinal tricarbonyl compounds. Similar mechanisms could operate in these reactions. If one equivalent of Grignard reagent reacted with one equivalent of ethyl benzoylglyoxylate (III), normal addition could proceed as outlined.

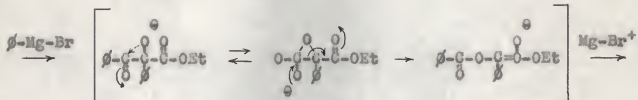
III $\xrightarrow[2.\ H_3O^+]{1.\ \phi\text{-Mg-Br}}$

VIII

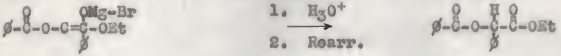
However, if rearrangements occurred they might follow a mechanism similar to that postulated previously. The ethyl benzoylglyoxylate molecule would have a partial positive charge on the carbon of the center carbonyl which would be attacked by the negative phenyl radical of the phenyl magnesium bromide. The negatively charged oxide type oxygen could then attack the carbon of an adjacent carbonyl group. Two possibilities arise as to the further course of reaction due to the non-symmetrical nature of III. The ethylene oxide type ring could form at the carbonyl adjacent to the phenyl or at the carbonyl adjacent to the ethoxyl. If the former is true, the course of subsequent rearrangements could be as follows.

III $\longrightarrow$ 

III_a

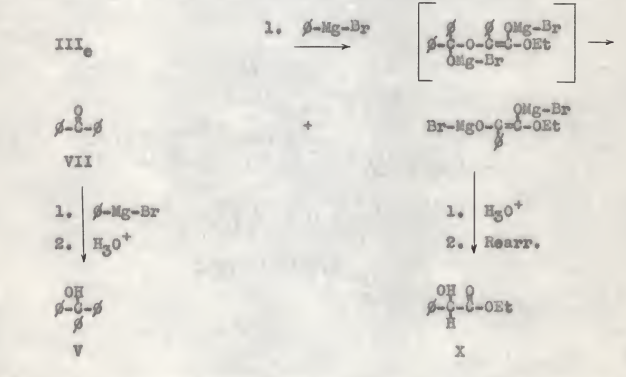


III_b III_c III_d



III_e IX

The product with one equivalent of Grignard would thus be the benzoyl derivative of ethyl mandelate. If excess Grignard reagent were to be employed, the reaction could proceed as follows.



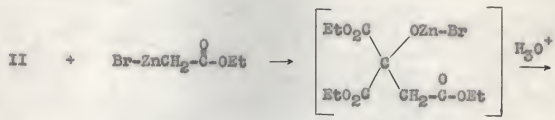
VII V X

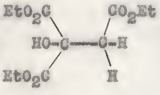
If, however, the carbethoxyl rearrangement should occur, the reaction upon addition of an excess of phenyl magnesium bromide could proceed as follows.

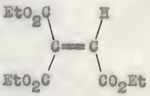
It seems improbable that the carbethoxyl rearrangement will occur as shown above, in view of the work of Lapkin and Golovkova (9) in which they reported direct addition of a Grignard reagent to the middle carbonyl of ethyl mesoxalate (II) without rearrangement.

In view of this it was postulated that equivalent portions of ethyl alpha-bromoacetate, ethyl mesoxalate and zinc might yield

an addition product which could lose water to give tricarbethoxyethylene.







XII

Suitable experiments were designed and carried out in an effort to elucidate the courses and, if possible, the mechanisms of the reactions of organometallic reagents with several vicinal tricarbonyl compounds.

EXPERIMENTAL

Preparation of Vicinal Tricarbonyl Compounds

Preparation of Diphenyl Triketone. A sample of diphenyl triketone hydrate mp. 89-91°, prepared by the method of Bigelow and Hanslick (1) was distilled at reduced pressure as an orange solid mp. 68-70°.

Preparation of Ethyl Benzoylglyoxylate. The method of Wahl (17) was used in the preparation of ethyl benzoylglyoxylate.

The apparatus consisted of a one liter three necked flask equipped with a mechanical stirrer, a 500 ml dropping funnel, and

a water condenser. To the top of the condenser was connected a glass tube which led to two drying towers filled with anhydrous calcium chloride. The towers were connected in series to a safety flask which, in turn, was attached to two gas absorption bottles of the sintered disc type. These bottles were then connected to another safety flask which, in turn, was connected to a gas washer.

Ethyl benzoylacetate (400 g, 2.02 moles) was placed in the absorption bottles, 200 g in each bottle, and the bottles were then immersed in an ice salt bath. Arsenious acid (600 g) was placed in the one liter three necked flask and nitric acid (540 ml, sp. gr. 1.42) was placed in the dropping funnel. Upon addition of the acid, nitrogen trioxide was generated and was bubbled through the ethyl benzoylacetate in the absorption flasks for approximately two and one-half hours. During the latter part of the addition the liquids became colored and then solidified to an orange crystalline solid. The solid was melted on a steam bath and transferred to a one liter flask to which was added acetic anhydride (80 ml) and ether (200 ml). The flask was then immersed in an ice salt bath, and nitrogen trioxide was again passed through for an additional two and one-half hours. The absorption bottle was disconnected, and drying tubes containing calcium chloride were attached. The flask was left immersed in the ice bath and allowed to come to room temperature very slowly. After 48 hours the ether was removed on a steam bath, and the residue was distilled under reduced pressure. A clear yellow oil distilled from 120-155° at 43 mm and crystallized in the receiver. The receiver was changed

when the temperature reached 155° and a second fraction distilled from 155-184° at 38 mm, which also crystallized on cooling. The latter fraction was dissolved in ether (150 ml) and the solution was washed with five portions (50 ml each) of a saturated brine solution, twelve portions (50 ml each) of a one to one saturated brine and 20 percent potassium carbonate solution, and finally with five portions (50 ml each) of saturated brine. This washed solution then was dried over anhydrous sodium sulfate for 24 hours, the ether was removed, and the residue was distilled at reduced pressure. A golden yellow oil distilled at 125-175° at water pump pressure. This golden yellow oil was diluted with an equal volume of ether, washed with five portions (50 ml each) of a one to one saturated brine and 20 percent sodium carbonate solutions, and finally with five portions (50 ml each) of saturated brine. The ether solution was dried over anhydrous sodium sulfate for 24 hours. The ether was removed and the residue was distilled at reduced pressure through a fractionating column. There was obtained 13.3 g (3 percent) of a golden yellow oil, bp. 115-118° at 2 mm, $n_D^{19.5}$ 1.5148.

Preparation of Ethyl Mesoxalate. Ethyl mesoxalate was prepared by the method of Dox (4). The apparatus was identical to that used for the preparation of ethyl benzoylglyoxylate by the method of Wahl (17).

Ethyl malonate (200 g, 1.25 moles) was placed in each of two absorption bottles, and these were immersed in an ice salt bath. Nitrogen trioxide generated by the reaction of arsenious acid (273 g) and nitric acid (241 g, sp. gr. 1.42) was bubbled through

the ethyl malonate for approximately two and one-half hours during which time the solution became a very dark green. The generator was then disconnected from the absorption bottles, and drying tubes filled with anhydrous calcium chloride and Ascarite were connected to the bottles which were then allowed to stand for several days during which time the solution became almost colorless. The solution was then distilled under reduced pressure to give 85 g (39 percent) of a green yellow oil, bp. 106-130° at 25 mm.

Reactions of Organometallic Reagents with Vicinal Tricarbonyl Compounds

Reaction of Diphenyl Triketone with Phenyl Magnesium Bromide. Oven dried magnesium turnings (0.875 g, 0.036 mole) and an iodine crystal were placed in a 500 ml round bottom three necked flask. The flask was fitted with a mechanical stirrer, dropping funnel, and a condenser capped with a drying tube containing Ascarite and anhydrous calcium chloride. Bromobenzene (5.65 g, 0.036 mole) in sodium dried ether (50 ml) was added dropwise with mechanical stirring to the magnesium turnings over a two-hour period. The resulting solution was dark brown in color. This same procedure was followed for all Grignard preparations.

Diphenyl triketone (8.6 g, 0.036 mole) was dissolved in sodium dried ether (150 ml) in a one liter round bottom three necked flask equipped with a mechanical stirrer, dropping funnel, and a condenser capped with a drying tube containing Ascarite and anhydrous calcium chloride. The prepared Grignard reagent was then added dropwise with stirring over a period of 40 minutes to the

solution of diphenyl triketone. Upon addition of the Grignard reagent a yellowish orange precipitate was formed. The reaction mixture was stirred for approximately two hours and then decomposed with saturated ammonium chloride solution. The decomposed solution was extracted with ether, the ether was removed by heating, and the product was crystallized from ethyl alcohol and water to give one and one-tenths grams (ten percent) of a white crystalline solid, mp. 121-122°. This solid gave a mixed melting point of 122-123° with an authentic sample of the benzoate of benzoin prepared by the benzoylation of benzoin in pyridine. This confirmed the work of Kohler and Erickson (8).

Reaction of Ethyl Mesoxalate with Phenyl Magnesium Bromide. A Grignard reagent was prepared from magnesium turnings (9.72 g, 0.4 mole) and bromobenzene (62.8 g, 0.4 mole). This Grignard reagent was then transferred by nitrogen pressure through a glass tube to another graduated dropping funnel. Ten ml of the Grignard reagent was standardized according to the method of Gilman, Wilkinson, Fishel, and Meyer (5).

A one liter three necked flask was thoroughly dried by heating in a dry current of nitrogen. This flask was fitted with a mechanical stirrer, water condenser, and the graduated dropping funnel containing the Grignard reagent. The funnel and condenser were both capped with drying tubes containing calcium chloride and Ascarite. Ethyl mesoxalate (49.0 g, 0.28 mole) and sodium dried ether (200 ml) was placed in the flask which was immersed in an ice salt bath maintained at -5 to -10°. One equivalent of phenyl magnesium bromide was then added dropwise with stirring to

the ethyl mesoxalate over a period of two hours. The yellow reaction mixture stood at room temperature for 24 hours and then was decomposed with ice and sulfuric acid. The etherial layer was separated and the aqueous solution was extracted with six portions of ether (100 ml each). All extracts were combined. The ether was removed on a steam bath, and the residue was distilled at reduced pressure. A colorless oil distilled from 52-59° at 1.5 mm. Further distillation gave a second pale yellow fraction over the wide distilling range of 60-105° at 1.0 mm.

Reaction of Ethyl Mesoxalate with Ethyl Alpha-bromoacetate. The method was adapted from those discussed by Shriner (15), and, since zinc produced no reaction, magnesium was utilized instead.

Dried magnesium turnings (2.74 g, 0.11 mole) were placed in a 500 ml round bottom flask. To the flask was added ethyl mesoxalate (19.5 g, 0.11 mole) and ethyl alpha-bromoacetate (18.6 g, 0.11 mole) prepared by the method of Vanino (16), sodium dried benzene (60 ml), and sodium dried ether (30 ml). A reflux condenser was attached, and the mixture refluxed for approximately two hours, during which time the reaction mixture turned to a yellowish brown color and most of the magnesium turnings dissolved. The solution was then allowed to stand for approximately 48 hours.

The reaction mixture was decomposed with ice and sulfuric acid. The ether-benzene layer was separated, and the aqueous layer was extracted with two portions of ether (50 ml each). All of the ether and benzene extracts were combined and dried over anhydrous sodium sulfate. The solvent was removed by heating, and the residue was diluted with ether (75 ml) and an equal volume of

acetic anhydride (75 ml). This solution was refluxed for one and one-half hours during which time it acquired a deep brownish red color.

The ether and acetic anhydride were removed under reduced pressure, and distillation was continued to give a major fraction, four grams, of pale yellow oil, bp. 95-99° at 0.25 mm.

Analysis calculated for $C_{11}H_{16}O_6$ (tricarbethoxyethylene): C, 54.09; H, 6.56. Found: C, 54.09, 53.39; H, 6.83, 6.63.

Saponification equivalent calculated for $C_{11}H_{16}O_6$, 81.3: Found, 90.2.

Reaction of Ethyl Benzoylglyoxylate with Phenyl Magnesium Bromide. The Grignard reagent was prepared from magnesium turnings (9.33 g, 0.384 mole) and bromobenzene (60.28 g, 0.384 mole), then was transferred by nitrogen pressure through a glass tube to another graduated dropping funnel. The Grignard solution was standardized according to the method of Gilman, Wilkinson, Fishel and Meyer (5).

A one liter three necked flask was thoroughly dried by heating in a dry current of nitrogen. This flask was fitted with a mechanical stirrer, water condenser, and the graduated dropping funnel containing the Grignard reagent. The funnel and condenser were both capped with drying tubes containing Ascarite and anhydrous calcium chloride. Ethyl benzoylglyoxylate (13.3 g, 0.064 mole) in sodium dried ether (200 ml) was placed in the flask which was immersed in an ice bath. Three equivalents of phenyl magnesium bromide were then added dropwise with stirring to the ethyl benzoylglyoxylate over a period of 45 minutes. Upon addi-

tion of half of the phenyl magnesium bromide a brown solid formed but dissolved upon further addition of the Grignard reagent. The red brown mixture was stirred for an additional 40 minutes and decomposed with ice and sulfuric acid. The etherial layer was separated and the aqueous solution was extracted with four portions of ether (100 ml each). All extracts were combined, and the ether was removed on a steam bath.

The residue was refluxed with potassium hydroxide in alcohol for one and one-half hours in order to saponify any esters, and while still basic was extracted with three portions of ether (100 ml each). The ether solution of neutral compounds was evaporated and the residue diluted with petroleum ether from which was obtained a white crystalline solid mp. 161-162°. The solid was identified as triphenyl carbinol by a mixed melting point of 160-161° with authentic triphenyl carbinol and by a characteristic red color produced when dissolved in concentrated sulfuric acid.

The basic aqueous solution was charcoaled, filtered, and acidified with dilute sulfuric acid. The acidified solution was extracted with ether, the ether was evaporated, and the residue extracted with sodium bicarbonate. The latter was then extracted with ether and the aqueous solution was acidified and then extracted with ether. The ether was evaporated to give a white solid (0.6 g) which was recrystallized from hot water and gave a mp. 117.5-118.5° and a mixed melting point with authentic mandelic acid of 117-118°. The saponification equivalent calculated for mandelic acid ($C_8H_8O_3$) was 152, that found was 155.2.

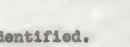
Reaction of Ethyl Benzoylglyoxylate with Phenyl Magnesium Bromide. The Grignard reagent was prepared from magnesium turnings (9.33 g, 0.384 mole) and bromobenzene (60.28 g, 0.384 mole), then was transferred by nitrogen pressure through a glass tube to another graduated dropping funnel. The Grignard solution was standardized according to the method of Gilman, Wilkinson, Fishel, and Meyer (5).

A one liter three necked flask was thoroughly dried by heating in a current of dry nitrogen. This flask was fitted with a mechanical stirrer, water condenser, and the graduated dropping funnel containing the Grignard reagent. The funnel and condenser were both capped with drying tubes containing Ascarite and anhydrous calcium chloride. Ethyl benzoylglyoxalate (22.5 g, 0.109 mole) in sodium dried benzene (150 ml) was placed in the flask. An excess of phenyl magnesium bromide was then added dropwise with stirring to the ethyl benzoylglyoxylate over a period of 40 minutes while a gentle reflux was maintained. The red brown reaction mixture was refluxed with stirring for 10 hours and then decomposed with ice and sulfuric acid. The benzene layer was separated, and the aqueous solution was extracted with three portions of ether (100 ml each). All extracts were combined, and the ether and benzene was removed on a steam bath.

The residue was refluxed with potassium hydroxide in alcohol for one and one-half hours and then extracted with four portions of benzene (50 ml each) and three portions of ether (50 ml each). The benzene and ether were evaporated and the residue diluted with petroleum ether to give triphenyl carbinol (8.0 g, 28 percent)

KANSAS STATE COLLEGE LIBRARIES

mp. 161-162°. The identity was shown by a mixed mp. 161-162° with authentic triphenyl carbinol and by the production of a red color when dissolved in concentrated sulfuric acid. The filtrate from the above separation was distilled at reduced pressure to give as a major fraction four grams of an orange viscous liquid bp. 170-205° at 3 mm. The residue of this distillation was diluted with ether and filtered to yield a white solid (0.4 g) which was recrystallized from 1,4-dioxane and water and gave a mp. 190-190.5°. This latter compound was not identified.

The aqueous solution from the saponification was charcoaled, filtered, and acidified. Upon cooling, this acidified solution yielded two grams of a white crystalline solid mp. 234-235° which gave off carbon dioxide upon additional heating. An analysis of this compound gave C, 78.69, 78.68; H, 5.68, 5.86. In view of the reactants involved in this reaction, the most reasonable formula to agree with these percentages was  This compound, however, was not identified.

The filtrate was ether extracted, and the ether was evaporated to give a white crystalline solid (0.1 g) with a mp. 117-118° and a mixed mp. 117-118° with mandelic acid, thus proving its identity.

Reaction of Ethyl Benzoylglyoxylate with Phenyl Magnesium Bromide. The Grignard reagent was prepared from magnesium turnings (9.33 g, 0.384 mole) and bromobenzene (60.28 g, 0.384 mole). The flask containing the Grignard reagent was placed in an ice bath and ethyl benzoylglyoxylate (15.0 g, 0.073 mole) was then added dropwise with stirring over a period of 30 minutes. The

red brown mixture was stirred for approximately two hours and then decomposed with ice and sulfuric acid. The etherial layer was separated, and the aqueous solution was extracted with three portions of ether (100 ml each). All extracts were combined, and the ether was removed on a steam bath.

The residue was refluxed with sodium hydroxide in alcohol for one hour and then extracted with six portions of ether (75 ml each). The ether was evaporated to give a white crystalline solid (6.0 g, 31.6 percent) which was recrystallized from carbon tetrachloride and proved to be triphenyl carbinol by its mp. of 161-162° and by a mixed mp. of 161-162° with authentic triphenyl carbinol. The usual red color was observed when it was dissolved in concentrated sulfuric.

The basic aqueous solution was charcoaled, filtered, acidified, and extracted with three portions of ether (50 ml each). The ether was evaporated, and a brown solid residue remained. This residue was extracted with sodium bicarbonate and then with ether. The aqueous basic solution was acidified and yielded a yellowish white solid which, upon recrystallization from hot water, had a mp. 117-118° and a mixed mp. of 93-94° with authentic mandelic acid. A mixed melting point of this white solid and authentic benzoic acid was 120-121°, thus proving it to be benzoic acid. A saponification equivalent as calculated for $C_8H_8O_3$ was 152, found was 149. Saponification equivalent calculated for $C_7H_6O_2$ was 122, found was 149. Since the mixed melting point appears to be the most reliable, it was thought that the white solid was benzoic acid.

DISCUSSION AND CONCLUSION

One of the most difficult and time-consuming phases of the study of the vicinal tricarbonyl compounds was the preparation and purification of any appreciable amount of the compounds used. Although the literature reported quite good yields, by following the identical procedures given we were unable to get yields even approaching those listed.

Kohler and Erickson (8) reported that the benzoate of benzoin was obtained as a result of the reaction of one equivalent of phenyl magnesium bromide with one equivalent of diphenyl triketone and not as a result of a rearrangement of the carbinol when the reaction mixture was decomposed with a saturated solution of ammonium chloride. The percentage yield of the benzoate of benzoin was, however, not reported. In duplicating this experiment, one equivalent of phenyl magnesium bromide reacted with one equivalent of diphenyl triketone to give a ten percent yield of the benzoate of benzoin. In obtaining this amount of the benzoate of benzoin it appears probable that some rearrangement did occur in the reaction, but this small yield also indicated the formation of other products which defied all efforts of isolation and purification.

The reaction of one equivalent of phenyl magnesium bromide with one equivalent of ethyl mesoxalate was less conclusive than the reaction with diphenyl triketone. It was believed that, due to the tendency of ethyl mesoxalate to form hydrates, a sizeable percent of the phenyl magnesium bromide was hydrolyzed as it was

added to the solution of ethyl mesoxalate. One product obtained from this reaction was thought to be the authentic ethyl mesoxalate because of the similarity of boiling point range and index of refraction as compared with ethyl mesoxalate.

A Reformatsky type of reaction with ethyl mesoxalate and ethyl alpha-bromoacetate and using magnesium turnings in preference to zinc was somewhat more successful than the Grignard reaction with ethyl mesoxalate. The hydrate formation tendency of ethyl mesoxalate was again believed to be a factor in the unsuccessful attempts to use zinc in this reaction. In order to maintain the reaction of ethyl mesoxalate, ethyl alpha-bromoacetate, and magnesium turnings, constant reflux was required. A distillation product with a small boiling point range was obtained from the reaction and carbon-hydrogen analyses of this product were well within the range for the postulated product, tricarbethoxyethylene. These results further confirmed the theory that the central carbonyl group of a vicinal tricarbonyl compound is the most reactive, and also indicated that, when an organometallic reagent reacts with ethyl mesoxalate, the reaction is an addition to the central carbonyl without rearrangement, as reported previously by Lapkin and Golovkova (9).

The products resulting from the reaction of excess phenyl magnesium bromide and ethyl benzoylglyoxylate appear to be quite dependent upon the reaction conditions. Three reactions were carried out with phenyl magnesium bromide and ethyl benzoylglyoxylate using different reaction conditions for each reaction. The same methods of decomposition and isolation of products were used, but

the resulting products were for the most part quite different. One compound, triphenyl carbinol, was obtained in fair yields from all three reactions. In the first two reactions the Grignard was added to the ethyl benzoylglyoxylate. The first reaction was carried out at 0°, the second, at the reflux temperature of benzene. Triphenyl carbinol was obtained in fair yields from both these reactions. Ethyl mandelate was also a reaction product, but the yield from the reaction carried out at 0° was much greater than from the refluxed reaction. In addition to the ethyl mandelate and triphenyl carbinol, three other products, an acid and two neutral products, were obtained from the refluxed reaction. The third reaction with phenyl magnesium bromide and ethyl benzoylglyoxylate was carried out by addition of the ethyl benzoylglyoxylate to the phenyl magnesium bromide which was kept at 0°. The products of this reaction were triphenyl carbinol and benzoic acid.

As a result of these reactions, it appears that the course of reaction of phenyl magnesium bromide with ethyl benzoylglyoxylate is subject to little control. This may be due to the large number of functional groups present and the high reactivity of the Grignard reagent. Due to insufficient data at this time, it seems unwise to say definitely that the postulated rearrangements occurred in this reaction. However, in view of the fact that triphenyl carbinol was obtained in all cases, it appears that cleavage of the ethyl benzoylglyoxylate molecule did occur.

SUMMARY

In reactions between mesoxalate compounds and organometallic reagents it appears that the reaction involves addition to the central carbonyl group with no rearrangement or cleavage of the molecule. The reactions of an excess of an organometallic reagent with an aromatic vicinal tricarbonyl compound apparently involves rearrangement and cleavage, but the course of the reaction is greatly altered by the reaction conditions. No consistent data were obtained which would support any single mechanism for the reactions.

ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation to Dr. Dexter B. Sharp, Associate Professor in the Department of Chemistry, for his guidance throughout the course of research, and also to those fellow students who assisted during the course of the experiments.

LITERATURE CITED

(1) Bigelow, L. A., and R. S. Hanslick
Diphenyl Triketone. Organic Syntheses. 13:38-40. New York: John Wiley and Sons, 1933.

(2) Bigelow, L. A., H. G. Rule, and W. A. P. Black.
The Catalytic Hydrogenation of Diphenyl Triketone. Jour. Chem. Soc. (London), 1935. p. 83-85.

(3) de Neufville, R., and H. von Peckmann.
Ueber das Diphenyltriketone. Ber. der Deutsch. Chem. Gesell. 23:3379. 1890.

(4) Dox, A. W.
Ethyl Oxomalonate. Organic Syntheses. 10:54-57. New York: John Wiley and Sons, 1930.

(5) Gilman, H., P. D. Wilkinson, W. P. Fishel, and C. H. Meyer.
The Quantitative Estimation of the Grignard Reagent. Jour. Amer. Chem. Soc. 45:150-158. 1923.

(6) Guyot, A., and A. Esteva.
Condensation des ethers mesoxaliques avec les carbures aromatiques. Compt. rend. 148:564-566. 1909.

(7) Guyot, A., and E. Michel.
Condensation des ethers mesoxaliques avec les amines aromatiques tertiaires. Compt. rend. 148:229-232. 1909.

(8) Kohler, E. P., and J. L. E. Erickson.
The Cleavage of Beta-Diketones. I. Cleavage by Organic Magnesium Compounds. Jour. Amer. Chem. Soc. 53:2301-2309. 1931.

(9) Lapkin, I. I., and A. I. Golovkova.
Steric Hindrance in Grignard Reactions. VI. Reactions of Esters of Keto Acids and O-Substituted Arylmagnesium Halides. Jour. Gen. Chem. (U.S.S.R.) 18:485-494. 1948.

(10) Lemaire, J.
Action of Mesoxalic Ester with Magnesium Alkyl Halides. Rec. trav. chim. 29:82-84. 1909.

(11) Meyer, A.
Sur la condensation de la phenyl isoxazolone avec l'ether mesoxalique. Compt. rend. 150:1765-1769. 1910.

(12) Sachs, F., and V. Herold.
Ueber Triketone. VI. Ber. der Deutsch. Chem. Gesell. 40:2714-2730. 1907.

(13) Sachs, F., and W. Wolff.
Ueber Triketone. III. Ber. der Deutsch. Chem. Gesell. 36:3221-3236. 1903.

(14) Schmitt, G.
Concerning the Products of Condensation of Mesoxalic Esters and Oxalacetic Esters with Cyanacetic Esters. Ann. chim. et phys. 12:406-432. 1908.

(15) Shriner, R. L.
The Reformatsky Reaction. Organic Reactions. 1:1-37. New York: John Wiley and Sons, 1947.

(16) Vanino, L.
Handbuch der Preparativen Chemie. 2:108. Stuttgart: Ferdinand Enke, 1937.

(17) Wahl, M. A.
Sur le benzoylglyoxalate d'ethyle. Compt. rend. 144: 211-214. 1907.

KANSAS STATE COLLEGE LIBRARIES

Date Due